Development of an Analysis Framework for Cuoricino and CUORE

M. Dolinski[1,2], T.D. Gutierrez[1], R. Maruyama[1,2], B. Quiter[1,2], A.R. Smith[1], N. Xu[1]
[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720*
[2] *University of California, Berkeley, CA 94720*

Discovery of neutrinoless double beta decay ($0\nu2\beta$) is one of the top two priorities in neutrino physics as described by a recent APS Multi-Divisional Neutrino Study [1]. LBL is currently involved in a $0\nu2\beta$ experiment called Cuoricino, a TeO_2 bolometer operating at the Gran Sasso National Laboratory (LNGS) in Italy. It is the largest experiment of its kind in the world and is poised to place the strictest upper limits on the rate of this exotic process. CUORE (Cryogenic Underground Observatory for Rare Events) is a proposed [2] next-generation experiment based on the same bolometric principles as Cuoricino. For more information, see the overview discussion entitled "The Cuoricino and CUORE Double Beta Decay Experiments" in this LBL NSD Annual Report.

One goal of the CUORE/Cuoricino group at LBL has been to develop an independent analysis capability to process raw data coming from Cuoricino. This provides an invaluable cross-check on the current analysis performed by our collaborators in Italy, but also develops important software and physics infrastructure that will contribute to potential future LBL analysis efforts in CUORE. The independent analysis framework will support the possibility of novel future analysis projects for researchers, postdocs, and students at LBL.

The analysis of Cuoricino data at LBL over the past year has proceeded in several stages that can be broken into four main parts:

1) Raw data decryption
2) Software development
3) Analysis algorithm development
4) Physics algorithm development

The first task was to decrypt the raw binary data. The data files were made available to us as was a rough outline of the word structure provided by our colleagues in Milan. Effort was dedicated to confirming the provided word structure and in generating various QA methods that verified we were reading the data correctly.

We are developing the LBL analysis framework using the powerful and flexible C++ based open source ROOT analysis package, developed at CERN and now widely used as a standard analysis platform in many areas of physics. The software development involved three inter-related aspects. First, the raw data were transferred into helpful analysis TTrees. To facilitate the analysis, various parameters are included in the TTrees to allow for easy cuts and pulse selection. Determining the ideal set of pre-processed data to include in the TTrees that best compliments an analysis is an ongoing effort. Second, the development of meaningful C++ classes that provide intuitive access to the data in the TTrees. This was implemented in a pulse class that ultimately provided intuitive methods to access essential pulse information. Finally, we are developing a set of macros that utilize the TTrees and actually process the data by generating QA plots, pulse analysis, web displays, and ultimately spectra from which physics results can be extracted. The software development is an ongoing project and considerable progress was made this year in constructing and testing various classes, TTree structures, and macros.

We continue with the ongoing development of algorithms to extract meaningful physics from the raw data. This includes three areas of activity. First, pulse shape analysis involves the classification, understanding, and filtering of the multitudes of pulses that have been generated by Cuoricino. Second, anti-coincidence algorithms are being developed to reduce and/or identify correlations between channels. Third, we continue to work on a gain stabilization method that utilizes the standard heater pulses available in the raw data.

Using our current software and algorithms we are able to obtain an energy resolution (FWHM) between approximately 11 keV and 20 keV of the ^{208}Tl line at 2615 keV for the non-pathological channels amongst those tested in calibration data. These numbers should be compared to the recent official values obtained by the collaboration which are between 4 keV and 9 keV, also depending on the channel. With improved gain correction methods, a complete arsenal of optimal filters and anti-coincidence methods, and use of the full data set we expect to soon match the resolution quoted by our collaborators.

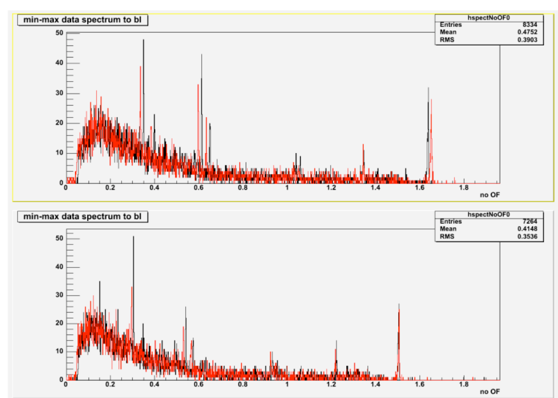

FIG. 1: Typical U+Th uncorrected calibration spectra (counts versus volts) from two crystals (top and bottom figures). The black and red lines represent different tests of the optimal filter algorithm.

REFERENCES

[1] The Neutrino Matrix, American Physical Society Joint Study on the Future of Neutrino Physics (2005).

[2] R. Ardito *et al.*, hep-ex/0501010 (2005).